Technical report
Perceptions of Computer Science among first year students at the University of the Witwatersrand

Vashti Galpin and Ian Sanders
School of Computer Science, University of the Witwatersrand
Johannesburg, South Africa

September 22, 2005

Abstract

This technical report presents research that investigates how the perceptions of Computer Science students at the University of the Witwatersrand located in Johannesburg, South Africa change from the start of their first year courses to the end of these courses. The research is motivated by our innovative curriculum which aims to present a broad picture of Computer Science. Most of the students' opinions did not change strongly, or alternatively there were changes in both directions. Significant changes included more students becoming positive about their own understanding of Computer Science, fewer students believing that Computer Science and mathematics are closely related, more students becoming aware of female Computer Scientists, and students becoming less positive about working with computers. Although students became more positive about their understanding of Computer Science, this was not demonstrated in their answers to questions about their knowledge. The majority of students found the courses differed from their expectations, and commented that they were too theoretical. Gender differences were also considered.

1 Introduction

This paper describes research into first year Computer Science students' attitudes at a South African university, the University of the Witwatersrand, located in Johannesburg. Our experience and prior research [Herbert 2000; Sanders and Galpin 1994] have shown that students often only have a narrow understanding of the nature of Computer Science, even when they have chosen to study it, and that they often make a strong link between Computer Science and programming, to the exclusion of other aspects of the discipline. This is most likely due to lack of career counselling, and an introduction to computing at school level that focusses on applications, such as word processing, and programming. Another possible explanation for lack of understanding is the diversity of the discipline, since it contains aspects of science, engineering and mathematics [Denning *et al.* 1989] and because it is not well-defined [Nielsen *et al.* 1998].

Other research has also shown incorrect perceptions such as that computing careers only involve programming, there are limited career opportunities, there is little interaction with people, and that computing careers are linked to administration or secretarial work [Greening 1998;

Durndell and Thomson 1997; Craig 1997; Teague and Clarke 1991; Clarke and Teague 1996; Ryan 1994; Symonds 2000].

The research was also motivated by our innovative curriculum [Sanders and Mueller 2000] which was developed to cope with the fact that some of our students have good school-leaving Mathematics marks, but no or little exposure to computers. This curriculum aims to broaden students' understanding of the discipline and to use the mathematical aspects of the discipline as an entry point to the discipline.

The research investigated students' attitudes at the beginning and towards the end of our first year courses. Over the courses, students become more confident about their understanding of Computer Science, they changed their opinion about the relatedness of Computer Science and Mathematics, and they became more aware of female Computer Scientists. They also became more negative about working with computers.

The structure of the document is as follows: the next section considers related research into attitudes, as well as giving details of the structure of the South African education system and our curriculum. Then we present the research methodology, the results and finally provide an interpretation and discussion of the results.

2 Related research

Over the last three decades, there has been much research into attitudes to computers, computing and Computer Science. In this section, research investigating changes in attitudes is considered, together with research into understanding of Computer Science and computing careers, as well as gender differences in attitudes. Since the focus of this research is first year at university, different approaches to introductory Computer Science courses are described. Next, some information specific to our country and institution is given, namely, the structure of the education system in South Africa, and the curriculum taught at the University of the Witwatersrand.

2.1 Changes in attitudes

Previous research has considered the effect of courses on student attitudes in different countries. In South Africa, Finnie [1987] investigated attitudes using Lee's attitude assessment instrument [Lee 1970], before and after a university first course in business computing which included the use of a financial modelling package and COBOL programming. After completion of the eight-month course, students became more negative about the value of computers and their impact, students were less in awe of computers and had a greater technical appreciation. Finnie notes the difficulty of implementing a control group who would not be exposed to the aspects of the course. A second South African study measured attitudes before and after a Computer Literacy course at another university [Burger and Blignaut 2004]. After the course, students were more anxious, were more negative, liked computers less and had less confidence in their abilities. The authors hypothesised that these effects may be reduced as students gained more experience.

Staehr *et al.* [2001] compared attitudes before and after an introductory computing course at an Australian university. They found the students' liking of computers decreased by the end of the course. They speculate that this could be "due to over exposure to computers or the competition for scarce resources" [Staehr *et al.* 2001, p.507].

Beyer and her colleagues have examined how the opinions of Management Information Systems and Computer Science students changed over a semester at an American university [Beyer *et al.* 2004, 2005]. They note the importance of not assuming that students' attitudes are fixed, as changes that occur during the course may remove the need for intervention. The results are mixed. For example, over time female Computer Science major students became more negative about the statement that Computer Scientists enjoy being around people whereas male Computer Science major students became more positive about this statement.

The prior research that has considered changes in attitudes generally has found that students become more negative, although when considering differences between genders as in the research of Beyer *et al.* [2005] a more complex picture emerges.

2.2 Content and understanding of Computer Science

Other research has considered what students or potential students know about Computer Science and what they expect from Computer Science courses. Greening [1998] surveyed Australian school children who were taking Computer Studies in the last two years of high school. Of the sample, 58% were unable to give a definition of Computer Science and the remainder gave partial definitions. Even students who were planning to study computing at university did not have a good understanding of the discipline. The students were also unclear about what they would expect to learn in an introductory computing course with answers ranging from programming, general usage skills, use of applications, and hardware to a repeat of the high school syllabus, and 39% gave null or trivial answers. When asked about whether mathematical ability was necessary to write programs, 46.4% were neutral, 35.8% agreed and the remainder disagreed. Of the sample, 72.2% thought all first computer courses should teach spreadsheets, 71.8% database design, 70.3% graphics programming, 67.8% multimedia, 61.9% programming, 58.3% network programming, 48.9% algorithm design, 47.6% games programming, 31% integrated circuit design, and 25% artificial intelligence. The results indicate that students appear to have little understanding of the nature of Computer Science or what to expect in an introductory university course. Scragg and Smith [1998] found that students in an introductory computing course at an American university believe that mathematics plays a large role in Computer Science.

Moore *et al.* [1994] developed a tool to investigate attitudes. They considered enjoyment of Computer Science, the value of Computer Science, the role of programming in Computer Science and the role of science in Computer Science. Of interest to the research reported in this paper, is the fact that there was high agreement with the statement that ‘There is more to Computer Science than programming’.

Australian Bachelor of Computing and Information Technology students found their courses different to what they had expected: “the course was regarded as very hard, involving more programming and maths than was expected” as well as “too theoretical and impractical” [Nielsen *et al.* 1998, p.89].

In South Africa, research investigating students starting Science degrees found that students were unclear of the content of Computer Science with many associating it strongly with programming, some with the use of application software such as word processors and others only giving nonspecific answers [Herbert 2000]. Among students planning to study Computer Science about a quarter of the comments were not specific, and half the sample mentioned programming. The predominant reason given among students who had chosen not to study Computer Science was a desire to follow a different field of study; other reasons mentioned included Maths marks that were too low for admission, lack of interest in computers and computing careers and lack of knowledge about computers and Computer Science [Herbert 2000].

In general, students did not have a clear idea of the nature of computing or Computer Science, as is shown by responses in surveys from a number of countries. This may be explained in part by the complexity of defining what Computer Science is [Denning *et al.* 1989]. Other research has investigated perceptions of careers, and this is discussed in the following section.

2.3 Perceptions of computing careers

As well as not understanding what will be taught in Computer Science courses, students are confused about careers. Research by Durndell and Thomson [1997] showed that students studying business or natural science at a Scottish university choose not to study computing because of misperceptions about the careers available. They did not want to work in front of a computer all day and believed studying computing would remove them from contact with people. They also expressed greater interest in people than objects. Other research has shown similar results about the solitariness of computing careers [Greening 1998; Clarke and Teague 1996; Symonds 2000]. Another misperception, particularly amongst female respondents, is that studying computing leads to secretarial and administrative careers [Craig 1997; Clarke and Teague 1996; Symonds 2000].

Nielsen *et al.* [1998] found that the Australian students in their sample were unclear about the differences between using computer systems and developing software for them. In contrast, the American and Finnish students had a better understanding which may be explained by the fact that they were, on average, older. They also found that students had difficulty in describing the types of career they wanted, although this was less of a problem for the more mature students and the Asian students.

Research has shown that students perceive that computer professionals will use a computer in their work, design computer programs, undertake system analysis and design [Craig *et al.* 2002b]. The sample consisted of students from Australia, Britain, Hong Kong and the USA taking first year introductory programming courses who selected activities from a given list. The same questionnaire given to second-year Computer Science students in South Africa showed that the students perceive that computer professionals undertake system analysis and design, design computer programs and create databases [Craig *et al.* 2002a]. Few students chose the following activities: computer games, writing documentation, creating spreadsheets and doing mainly word processing.

Another South African study of students starting Science degrees found that approximately 40% of the sample did not know what jobs a Computer Science degree would qualify one for; considering only the students planning to study Computer Science, the proportion of those not knowing was about a third [Herbert 2000]. Around two-thirds of the sample believed that there were good jobs for Computer Scientists [Herbert 2000].

2.4 Gender differences in attitudes

Much has been written about gender differences in computer usage and attitudes. Surveys of this research as well as suggested explanations for the differences can be found in the papers of Teague [1996] and Gürer and Camp [2002].

In the South African context, Moore investigated secondary school students' attitudes towards computers using a sample of Matric students [Moore 1994] and found female participants were more negative towards computers. Computer usage was more correlated with positive perceptions than gender was; the boys were more positive because they used computers more often. Pike surveyed English-speaking Western Cape Matric students [Pike *et al.* 1993] and found that gender did not affect attitudes towards computers. In contrast, a study of Afrikaans-speaking secondary school students showed that the female students were less interested in Computer Science [Swanepoel 1990].

At the University of the Witwatersrand, first year male Computer Science students were more confident about their ability to study computing than their female peers [Sanders and Galpin 1994]. They were also more likely to have chosen to study Computer Science because of their liking for computer games. The female students were more positive about women's ability to succeed at Computer Science. A subsequent study showed a lack of positive female role models, and the perception of Computer Science as male-dominated. Both male and female respondents were positive that women could succeed at Computer Science, and that there were good careers for Computer Scientists [Herbert 2000]. When considering male and female students who were planning to study Computer Science, almost a third of male students were vague about the content of Computer Science whereas few women were vague, and about a fifth of the female sample expected programming and how to use a computer as the course content with few men giving this response.

Clarke and Finnie's research found no significant gender differences between Commerce students in their attitudes to computers [Clarke and Finnie 1998] in contrast to Finnie's earlier study in which female students were less positive, had a greater fear of computers and less technical appreciation [Finnie 1987]. A later survey considered Science, Commerce and Arts students at the same university and found that males were more positive about computers, but found no significant difference in terms of anxiety [Clarke 2000]. Smith and Oosthuizen [2003] found that female students were more apprehensive about the impact of computers on society.

In summary, prior research into gender and attitudes in South Africa has not been consistent with differences found in some cases and not others. Because of the prevalence of negative attitudes and misperceptions, academics have considered how introductory computer science should be taught. The next section reviews different approaches to introductory courses.

2.5 Approaches to introductory Computer Science courses

Computing Curriculum 2001 [The Joint Task Force on Computing Curricula 2001] highlights the different ways that introductory Computer Science courses can be taught. Historically, introductory courses have focussed on programming, and this remains the predominant model in the USA, and probably worldwide. There are a number of weaknesses with this approach including providing the impression that Computer Science is programming, delaying foundational theoretical issues until later in the curriculum, focussing on the syntax of a particular language without dealing with algorithms and disadvantaging students who have no programming experience without challenging those with experience (and possibly bad programming habits). Programming-first curricula are classified as imperative-first, objects-first and functional-first.

Computing Curriculum 2001 also presents three non-programming introductory curricular: breadth-first which aims to provide an overview of the field of Computer Science, algorithms-first which focusses on algorithms without programming and hardware-first which starts with circuits and considers successive layers of abstraction. Another dimension of this debate is whether discrete mathematics is given separately or as part of the introductory Computer Science courses. The first year courses taught at the University of the Wiwatersrand (which will be described in Section 2.7) can be classified as breadth-first courses.

As this document considers the teaching of Computer Science in South Africa, some background on the educational system is presented next.

2.6 Education in South Africa

The South African education system requires all learners to complete seven years of compulsory primary schooling starting from the year in which the learner turns seven (Grades 1 to 7) followed by up to five years of secondary schooling (Grades 8 to 12). A learner can leave school at the end of the year in which they turn fifteen or complete Grade 9. In their secondary education, students typically do ten subjects in Grades 8 and 9 and this number is then reduced to six from Grade 10 when the learners are typically 14 to 15 years old. These six subjects must include at least two of South Africa's eleven official languages. Subjects can be taken at either the Higher Grade or Standard Grade levels. The final school leaving examination is the Senior Certificate Examination which also serves as the matriculation exemption examination (Matric) and is based on the subjects taken in Grades 10 to 12.

The results of the Matric exam are used to determine whether the learners will be offered entrance into university and in many cases used to determine if they will be allowed to register for a particular degree. In order to be accepted to study Computer Science, a sound overall Matric symbol and good pass in Mathematics is usually required. A standard Bachelor's degree takes a minimum of three years of full-time study (Engineering and Medicine are different), after which students can read for a Honours degree (one year of full time study). Some students then elect to complete Higher Degrees – Masters or PhDs. Most graduates with majors in Computer Science will initially have obtained Bachelor of Science degrees, and those students majoring in more business-related areas such as Information Systems obtain Bachelor of Commerce or similar degrees.

The South African education system is still affected by the legacy of the apartheid system. Students in poorer areas such as rural areas and the formerly black urban townships are still educationally disadvantaged because of their schools' inability to levy fees to increase resources, particularly computer laboratories [Vally and Dalamba 1999]. This means that many students do not gain exposure to computers at school and do not have the opportunity to select Computer Studies as one of their Matric subjects. In addition, the country suffers from a shortage of qualified mathematics and science teachers [Department of Education 2001] and hence many students are not well enough prepared for the Matric exams and thus for entrance into university.

2.7 Computer Science curriculum at Wits

In 1999 the School of Computer Science at the University of the Witwatersrand (Wits) introduced a new first year curriculum [Sanders and Mueller 2000]. The design of the curriculum was based on the principles of making the first year courses accessible to all students with the required mathematics ability/potential, breaking down the "Computer Science is programming" attitude which was prevalent among students and shrinking the gap between the various groups in the student population. The aims of the course are to give an introduction to Computer Science; to cover the basic principles upon which the courses in subsequent years build; to develop essential skills required in subsequent years; to motivate the students in the discipline of Computer Science; and to develop the correct attitudes required for tackling problems in the discipline.

At Wits the academic year is divided into 4 blocks each comprising approximately 7 weeks of lectures. In Computer Science, a course is typically taught over one block or in parallel with another course over two blocks at "half pace". At first year level Computer Science students have a total of five lectures (45 minutes each), a tutorial (also 45 minutes) and a two hour laboratory session each week. The courses in the new first year curriculum are discussed below.

- **Blocks 1 and 2 –** Basic Computer Organisation (BCO) and Fundamental Algorithmic Concepts (FAC) are taught in parallel. The *Basics* course (from 2004 a formal course called Basic Computer Concepts and before that part of the other courses but not actually assessed) runs in parallel with BCO and FAC but has only one lecture per week.

  BCO – Propositional logic, boolean algebra, relationship between logic & hardware, introduction into basic hardware building blocks, automata, simple von Neumann model,

			%			%			%
Age:	17	12	26.1	18	24	52.2	19+	8	17.4
Matric Maths:	HG A	14	30.4	HG B	17	37.0	Other	15	32.6
Race:	Black	12	26.1	Indian	14	30.4	White	16	34.8
Usage:	Prog	28	60.9	Appl	14	30.4	Never	4	8.7
Gender:				Female	15	32.6	Male	31	67.4
School:				Same sex	7	15.2	Co-ed	38	82.6
Computer Studies in Matric:				Yes	26	56.5	No	20	43.5
Home computer:				Yes	35	76.1	No	11	23.9
Plan to major in CS:				Yes	38	82.6	No	7	15.2

Table 1: Demographic information

low-level programs (2 lectures per week)

FAC – Basic graph theory, proof techniques and simple proofs (direct, inductive, contradiction, constructive), formal specifications, study of well known algorithms, verification of simple algorithms, analysis of simple algorithms, overview of analysis of algorithms, overview of programming languages and compilers (2 lectures per week)

Basics – Basic computer hardware, Linux, email, syntax of the chosen programming language, translating an algorithm into code, desk checking, compiling, error detection, error correction (1 lecture per week)

- **Block 3 –** Data and Data Structures (DDS)

  DDS – Representation of data, data structures (such as lists, stacks, queues), recursion, dynamic data structures, study of well known algorithms on these data structures, analysis of these algorithms (4 lectures per week)

  Basics – Plenty of exercises using arrays, procedures, records, pointers and files (1 lecture per week)

- **Block 4 –** Limits of Computation (LOC)

  LOC – Theory of computation (including undecidability and the halting problem), social issues (including ethics and responsibilities of scientists and professionals), artificial intelligence (including game-playing, expert systems and natural language processing) (4 lectures per week)

  Basics – Overview of databases, overview of networks, the use of the internet, markup languages (1 lecture per week)

We believe that these courses give students the knowledge and skills to succeed in our later courses.

The research presented in this document considers how our courses affect our students' perceptions of the discipline. The next section describes the methodology used after which the results of the research are presented and discussed.

	Unchanged		*Changed*				
Before	*Yes*	*No*	*No*	*Yes*			
After	*Yes*	*No*	*Yes*	*No*	n	p	
Do you have a clear idea of what Computer Science involves?	53.5	16.3	27.9	2.3	43	$<$0.01	*
Do you think Computer Science and mathematics are closely related?	68.9	6.7	0.0	24.4	45	$<$0.01	*
Are you interested in learning the technical details about computers? (e.g. computer hardware, engineering, networking etc.)	77.8	4.4	2.2	15.6	45	0.07	
Are you interested in learning the applications of computers? (e.g. Artificial Intelligence, Database design etc.)	82.2	0.0	2.2	15.6	45	0.07	
Are you interested in learning the fundamentals of computer science? (e.g. algorithms, data structures etc.)	76.1	4.4	6.5	13.0	46	0.51	
Are you studying Computer Science to learn programming?	52.3	18.2	11.4	18.2	44	0.58	
Was Computer Science your first subject choice?	70.5	15.9	4.6	9.1	44	0.69	
Do you plan to major in Computer Science?	80.0	11.1	4.4	4.4	45	1.00	
Are you interested in learning how to use a computer? (e.g. word processing, spreadsheets etc.)	69.6	17.4	6.5	6.5	46	1.00	
Are you interested in learning about scientific computing? (e.g. DNA sequencing, 3D graphics, modelling / simulation etc.)	95.6	0.0	0.0	4.4	45		

Table 2: Computer Science content and interest

3 Methodology

3.1 Sample and questionnaire

The sample consisted of 46 students, all of whom were attending university for the first time. They were all registered for our Computer Science I courses. There were 15 female students and 31 male students, with ages ranging from 17 to 21 with 78.2% of the sample 17 or 18 years old. The students were surveyed in the years 2000 and 2002, and there were no significant differences found using the Fisher Exact Test [Sheskin 2000] between the two year groups in terms of sex, age, Matric maths mark, type of school (co-ed or single-sex), race, Computer Studies in Matric, computer usage, home computer and plans to major in Computer Science. Demographic information is described in Table 1.

Since our first year consists of 4 courses spread over the year, and because some courses are prerequisites for other courses, the students for whom we obtained two questionnaires represent students who had success in the first two courses, and have done well enough in the mid-year exams, and hence are representative of those who are likely to persist to second and third year.

As we wanted to investigate the perceptions of new students, we excluded from the sample

	Unchanged		*Changed*				
Before	*Yes*	*No*	*No*	*Yes*			
After	*Yes*	*No*	*Yes*	*No*	n	p	
Do you know any women computer scientists in industry/academia?	15.2	45.7	34.8	4.4	46	$<$0.01	*
Do you know many women who work with computers?	19.6	41.3	26.1	13.0	46	0.24	
Do you know anyone who has studied Computer Science?	45.7	17.4	23.9	13.0	46	0.33	
Do you know anyone who works with computers as a profession?	61.0	17.1	14.6	7.3	41	0.51	
Do many of your friends use computers?	73.9	17.4	2.2	6.5	46	0.63	
Would you classify yourself (or do others classify you) as a computer nerd?	10.9	76.1	4.4	8.7	46	0.69	
Do you think of a computer scientist as a 'nerd' who talks/thinks only about computers?	4.6	84.1	6.8	4.6	44	1.00	
Do you have a computer at home?	73.9	19.6	4.4	2.2	46	1.00	
Are most of the people you know who like computers men?	69.8	9.3	11.6	9.3	43	1.00	
Do you think that there are good jobs available for people with Computer Science degrees?	95.6	0.0	2.2	2.2	45	1.00	
Are you confident of using new technology? (e.g. VCR, computers, remote controls)	100	0.0	0.0	0.0	46		

Table 3: Computer usage and role models

any students repeating the course or any student who had been at any university prior to the year of the survey.

The students completed a questionnaire on the first day of the course (which was also their first lecture at university) and then later in the year completed a similar questionnaire which had some additional questions relating to the course. See Appendix A. Questionnaires were matched before analysis.

3.2 Analysis

As our aim was to investigate how student perceptions changed, we used McNemar's test and the binomial sign test [Sheskin 2000] to determine whether results showed significant changes. Both of these tests assess whether there has been a significant change in a specific direction. For example, in a dichotomous question (one that requires students to answer yes or no), the McNemar test gives a significant result when the proportion of students that answered yes in the first questionnaire and no in the second questionnaire, is significantly larger than the proportion of students who answered no in the first questionnaire and yes in the second questionnaire (or vice versa), where the proportion is calculated with respect to the number of students who changed from the first questionnaire to the second. The null hypothesis is that the proportions

	Unchanged		Changed				
Before	*Yes*	*No*	*No*	*Yes*			
After	*Yes*	*No*	*Yes*	*No*	n	p	
Female	28.6	21.4	50.0	0.0	14	0.02	*
Male	65.5	13.8	17.2	3.5	29	0.22	
Computer Studies not taken in matric	36.8	26.3	36.8	0.0	19	0.02	*
Computer Studies taken in matric	66.7	8.3	20.8	4.2	24	0.22	
Used a computer without programming	30.8	23.1	46.2	0.0	13	0.03	*
Used a computer including programming	69.2	7.7	19.2	3.9	26	0.22	
Encouraged to study a science degree	48.0	12.0	36.0	4.0	25	0.02	*
Not encouraged to study a science degree	58.8	23.5	17.7	0.0	17	0.25	

Table 4: Further analysis: Do you have a clear idea of what Computer Science involves?

are equal, that is they are both equal to 0.5. The students that gave yes in both questionnaires or no in both questionnaires are not considered in the test. The binomial sign test is similar but applied to ordinal data (in this case, an Agree, Neutral, Disagree scale). As in the McNemar test, students who answered the same in both questionnaires are not considered. The binomial sign test determines if the proportion of respondents who have moved towards the Agree end of the scale is significantly larger than that of those who have moved towards the Disagree end of the scale (or vice versa). The null hypothesis is the same as that of the McNemar test.

4 Results

The results show that in general, student attitudes and perceptions appear to be resistant to change. The results described in this section are presented in Tables 2 to 8. The first four columns of these tables give the percentage of students with the combination of answers indicated in the column heading. This percentage is calculated with respect to the value given in the n column. This value is the number of students that answered some combination of yes and no on the two questionnaires – students that did not respond on one of the questionnaires are excluded. The next column gives the probability that there is a significant difference in the proportion of students switching, and an asterisk next to this value indicates whether it is significant at the 0.5 level, namely this indicates that the probability that the differences observed are due to chance is less than 5%.

4.1 Content, interests and role models

Tables 2 and 3 present the data for a number of statements with Yes and No responses. Table 2 covers questions relating to the content of Computer Science and students' interests. As can be seen, significant results are only found for the first two statements, one asking about their understanding of their knowledge of Computer Science and the other asking about their perception of the relationship between Computer Science and mathematics. These two statements will be discussed in more detail below.

For the rest of the statements, a large majority of students responded yes on both question-

	Unchanged		*Changed*				
Before	*Yes*	*No*	*No*	*Yes*			
After	*Yes*	*No*	*Yes*	*No*	n	p	
Female	71.4	7.1	0.0	21.4	14	0.25	
Male	67.7	6.5	0.0	25.8	31	$<$0.01	*
Computer Studies not taken in matric	73.7	0.0	0.0	26.3	19	0.06	
Computer Studies taken in matric	65.4	11.5	0.0	23.1	26	0.03	*
Used a computer without programming	76.9	0.0	0.0	23.1	13	0.25	
Used a computer including programming	64.3	10.7	0.0	25.0	28	0.02	*
Encouraged to study a science degree	80.0	0.0	0.0	20.0	25	0.06	
Not encouraged to study a science degree	52.6	15.8	0.0	31.6	19	0.03	*

Table 5: Further analysis: Do you think Computer Science and mathematics are closely related?

naires, and there were few students who changed their opinion between the two questionnaires. For the statement about studying Computer Science to learn programming, there were fewer double yes responses and more change in opinion, although almost equally balanced in terms of direction, hence the lack of significant difference.

Table 3 covers questions relating to computer usage, and role models. Only the question about female Computer Scientists gave a significant result, and will be discussed in more detail below. Students were positive about their ability to use new technology and the availability of good jobs. For questions about who likes computers, presence of a home computer, usage of computers by friends and knowing computer professionals, the majority answered yes on both questionnaires. The majority answered no on both questionnaires about being nerds and viewing Computer Scientists as nerds. More mixed responses were given for questions about knowing women who work with computers and knowing people who have studied Computer Science.

Further analysis of the data was done for all questions in Tables 2 and 3 for which there were no significant differences, in terms of gender, Matric Computer Studies, computer usage, and encouragement to study a science degree. No significant differences were found for any of these variables.

Further analysis was done for the three questions in Tables 2 and 3 where there were significant differences, and these are discussed in the next section. Note that there is a significant correlation (Φ co-efficient 0.9014 [Sheskin 2000]) between Matric Computer Studies and computer usage: 100% of those who had done Computer Studies had programmed, and of those who had programmed only 10% had not done Computer Studies. Hence, we would expect similar results for the group of students who had taken Computer Studies in Matric and those who had programmed; and similar results for the group of students who had not taken Computer Studies in Matric and those who had used a computer but not programmed.

4.1.1 Understanding of Computer Science

At the start of the academic year, only 55.8% of the sample (who answered the question) were convinced that they had a clear idea of what Computer Science involves. By the end of the

	Unchanged		*Changed*				
Before	*Yes*	*No*	*No*	*Yes*			
After	*Yes*	*No*	*Yes*	*No*	n	p	
Female	26.7	20.0	53.3	0.0	15	<0.01	*
Male	9.7	58.1	25.8	6.5	31	0.11	
Computer Studies not taken in matric	15.0	45.0	40.0	0.0	20	<0.01	*
Computer Studies taken in matric	15.4	46.2	30.8	7.7	26	0.11	
Used a computer without programming	7.1	35.7	57.1	0.0	14	<0.01	*
Used a computer including programming	21.4	42.9	28.6	7.1	28	0.11	
Encouraged to study a science degree	19.2	42.3	30.8	7.7	26	0.11	
Not encouraged to study a science degree	10.5	47.4	42.1	0.0	19	<0.01	*

Table 6: Further analysis: Do you know any female Computer Scientists in industry/academia?

year, this had increased to 81.4% with 27.9% switching from no at the start to yes later. The proportion switching was found to be significant using the McNemar test. Further analysis was done, and as in shown in Table 4, significant differences were found for female students, those who had not taken Computer Studies for Matric, those whose prior computer usage included applications, but not programming, those who had been encouraged to take a science degree, and those who have a computer at home. Note that for female students, those who did not take Computer Studies for Matric and those whose prior computer usage was applications, more than 60% of the respondents answered no in the first questionnaire.

4.1.2 Relationship between Computer Science and mathematics

Of the sample, 24.4% started the year with the belief that Computer Science and mathematics are closely related, but later in the year had changed their opinion. None of the sample changed their opinions from no to yes. This gave a significant result. Further analysis found significant differences, and as shown in Table 5, these occurred for male students, students who had taken Computer Studies for Matric, those who had done programming before university, and those not encouraged to study a science degree.

4.1.3 Female Computer Scientists

Of the sample, almost half answered no on both questionnaires when asked whether they knew female Computer Scientists in academia or industry, and 34.8% changed their answer from no to yes, a significant result. Further analysis showed significant differences for female students, those who did not take Computer Studies for Matric, those whose prior computer usage was applications, and those not encouraged to study a science degree, as shown in Table 6. Around a quarter of female students knew female Computer Scientists at the start of the year compared to 9.7% of male students.

4.1.4 Content and gender statements

For this part of the questionnaire, students were asked to indicate whether they agreed, disagreed or were neutral with respect to a list of statements. The results are shown in Table 7.

	Unchanged			*Changed*				
	A	*N*	*D*	*Pos*	*Neg*	n	p	
Working with computers is boring	0.0	6.8	70.5	20.5	2.3	44	0.01	*
Computer Science is not interesting because it involves working with machines instead of people	0.0	2.2	71.7	21.7	4.4	46	0.02	*
It is difficult to find interesting jobs in computer science	0.0	0.0	75.0	20.0	5.0	40	0.05	
I am interested in learning to use computers to solve practical problems; not in learning about the computer itself	17.5	15.0	12.5	35.0	20.0	40	0.14	
Computer Science involves mainly programming	12.8	18.0	28.2	20.5	20.5	39	0.60	
There are many jobs for people who have studied computer science	66.7	0.0	0.0	16.7	16.7	36	0.61	
Computer Science work involves mainly word processing	0.0	0.0	83.8	8.1	8.1	37	0.66	
I would prefer a male lecturer/supervisor to a female	0.0	19.5	31.7	34.1	14.6	41	0.06	
Boys like computer games more than girls	50.0	6.8	13.6	20.5	9.1	44	0.13	
I am confident that women can learn Computer Science	82.2	6.7	0.0	2.2	8.9	45	0.19	
Computer Science, Engineering and Maths are more appropriate fields for men than for women	4.6	6.8	61.4	18.2	9.1	44	0.19	
I would expect the top science student to be male	14.6	19.5	34.2	19.5	12.2	41	0.29	
I expect to see mostly men in Computer Science classes	30.2	7.0	14.0	27.9	20.9	43	0.33	
Men make better scientists than women	4.9	12.2	58.5	14.6	9.8	41	0.38	
Men are better at technical subjects than women are	9.8	17.1	41.5	14.6	17.1	41	0.50	

Table 7: Perceptions of Computer Science

The first three columns of figures indicate the percentage of students who did not change their opinions, the fourth column those who changed from Disagree to Neutral or Agree, or from Neutral to Agree, and the fifth column those who changed from Agree to Neutral or Disagree, or from Neutral to Disagree. These percentages are calculated with respect to the value in the n column which represents the number of students who answered Agree, Neutral or Disagree on both questionnaires and excludes the students who did not respond or chose Don't Know on one of the questionnaires. The column headed p represented the probability calculated by the binomial sign test, and significant results are indicated by an asterisk. Because a two-tailed test is required, the value used is 0.025 [Sheskin 2000]. Statements are grouped into two categories, those that focus on Computer Science content and employment, and those that focus on gender.

As can be seen from Table 7, significant differences were only found for two statements. For both statements, a significant portion of students moved towards agreeing with the statements, one which stated that working with computers is boring, and one which stated that Computer Science is not interesting because it is about machines rather than people. About 20% of the sample become more negative about working with computers and Computer Science, with around 70% remaining positive (reflected by their disagreement with the statements). Most of the movement was from disagreement to neutral. For the first statement, of the 9 students who changed their opinion, 8 moved to neutral, and for the second statement, of the ten students who changed their opinion, 70% moved to neutral. There were no significant changes by gender.

For the rest of the statements, the students were mostly positive about employment prospects, fairly definite that Computer Science was not mainly about word processing, and had mixed opinions about whether Computer Science involves mainly programming with changes of opinion in both directions. Students also had mixed opinions about whether they wanted to learn about using the computer to solve problems, or whether they wanted to learn about the computer itself, with changes in opinion in both directions. There were no significant changes by gender.

The second part of Table 7 considers statements relating to gender. There were no significant changes found. A further analysis was done by gender and no significant changes were found. The statement for which there was most agreement on both questionnaires and least movement asked about the respondent's belief that women can study Computer Science. For the three statements implying that men were better than women at science, engineering, and mathematics, most respondents disagreed on both questionnaires with statements with moderate changes of opinion in both directions. 30.2% of respondents agreed before and after with the statement that there would be mostly men in Computer Science classes, with movement in both directions, and about a third disagreed on both questionnaires with the statement that the top science student would be male with movement in both directions. 50% of the sample agreed on both questionnaires that boys like computer games more than girls, and most movement was towards agreement with this statement.

In general, although there were no significant differences found, the larger movement for all statements but one was in the direction of the less gender-neutral opinion. When considering male and female responses separately, female students more strongly disagreed with the statements that were sexist.

Table 8 presents some additional information. It has a similar structure to Table 7. No significant changes were found, although the last three questions have relatively low p values. Students were generally positive about their abilities – none chose the option poor in either questionnaire. There was a shift to prefer working alone rather than in groups, more students reported an increase in computer use rather than decrease, and more students reported an increase in visiting computer stores or reading computer magazines. Further analyses were done by gender but no significant changes were found for either gender.

	Good	Ave		Incr	Decr	n	p
	Unchanged			*Changed*			
	Good	*Ave*		*Incr*	*Decr*	n	p
How would you rate your skills at mathematics, analytical thinking and problem solving?	62.8	20.9		4.7	11.6	43	0.23
	Usual	*Some*	*Never*	*Incr*	*Decr*	n	p
Do you prefer working on projects alone rather than in groups?	21.7	47.8	0.0	23.9	6.5	46	0.03
	<2	*2-15*	*>15*	*Incr*	*Decr*	n	p
How many hours per week do you use a computer?	9.8	22.0	17.1	36.6	14.6	41	0.04
	Usual	*Some*	*Never*	*Incr*	*Decr*	n	p
Do you read computer magazines or visit computer stores?	15.2	41.3	10.9	21.7	10.9	46	0.15

Table 8: Skills' assessment, group work, weekly usage, and computer magazines and stores

4.2 Open-ended questions

Students were asked what jobs a Computer Science degree would enable one to do, what they wanted to do with their degree and what they expected to learn in a Computer Science course.

The results are presented in Tables 9 and 10. The job descriptions and course content items that appear in the tables represent those where 10% or more of the sample mentioned in it in one of the questions.

When asked in the first questionnaire about what jobs they would be qualified to do with a Computer Science degree, 21.7% didn't know and 67.4% said programmer. Other jobs mentioned with included analyst/system analyst, jobs involving networking and jobs involving development/design. 20% of respondents mentioned jobs for which it is very unlikely that a Computer Science degree would be required. 17% only mentioned programmer.

For the second questionnaire, 19.6% didn't know and 71.7% said programmer. Other jobs mentioned included analyst/system analyst, jobs involving networking and jobs involving development/design, and additionally jobs relating to the web, technician and system administration. 24% of respondents mentioned jobs for which it is very unlikely that a Computer Science degree is required. 17% mentioned programmer only, and 54% said programming on both questionnaires.

Students were also asked what they would like to do once they completed a Computer Science degree. For the first questionnaire, 37% did not know and 30.4% mentioned programming. The remaining responses which were all at less than 10%, consisted of jobs such as an analyst, networking, web-related jobs, technician, development/design, research, game design/programming and graphic designer. Only 4% of respondents mentioned jobs for which it is very unlikely that a Computer Science degree is required. 20% said programmer only.

For the second questionnaire, 30.4% didn't know or gave no response, 26.1% said programming, and 13% said development/design. The remaining responses which were all at less than 10%, consisted of jobs such as an analyst, networking, web-related jobs, technician, development/design, game design/programming and graphic designer, as well as system administration, databases, sales and entrepreneurial. 13% of respondents mentioned jobs for which it is very unlikely that a Computer Science degree is required. 17% said programming both before and after, and 26% said programmer only.

Students were also asked about what they would expect to learn in a Computer Science course. 13% said they didn't know or gave no response in the first questionnaire compared with 23.9% in the second questionnaire. Responses on the first questionnaire included programming, hardware, software, how computers work and how to use a computer. In the second questionnaire, responses included programming, algorithms, hardware. 26% said programming both before and after, and 9% said only programming on the first questionnaire, and 15% said only programming on the second questionnaire.

Looking at those who said that they had a clear idea of Computer Science and those who did not, the number in each group that said programming was about 50%. Since the number that were not clear about Computer Science on the second questionnaire was small (only 8), it is not possible to do further analysis of the differences.

4.2.1 Gender

When considering male and female students separately, no strong pattern emerges. Fewer female students chose 'Don't know' or gave no response in the second questionnaire (33.3% compared with 13.3% for the question about jobs) whereas more male students chose 'Don't know' or gave no response in the second questionnaire (16.1% compared with 22.6% for the question about jobs). A similar pattern occurred when asking the students about what they wanted to do with their degrees.

When asked about jobs, of the female sample, 53.3% mentioned programming in the first questionnaire, and 66.7% in the second, showing an increase. 40% mentioned programming both before and after, indicating that it was not necessarily the same students on both questionnaires. Responses at the 10% or greater level were the same as for the total sample, plus jobs involving the web for the first questionnaire, and consultant and jobs involving databases on the second questionnaire.

In the male sample, 74.2% mentioned programming on the first questionnaire and the same percentage on the second questionnaire. However, only 61% mentioned programming on both questionnaires, indicating that it is not the same students responding. Comparing responses of the male sample to those of the total sample, responses at the 10% or greater level were the same plus research for the first questionnaire, and the same except for jobs involving the web on the second questionnaire.

When asked about their own career plans, 20% of the female sample mentioned programming on the first questionnaire, and 13.3% on the second, showing a decrease. 7% mentioned programming both before and after, indicating different students responding on the two different questionnaires.

Considering their own career plans, 35.5% of the male sample mentioned programming in the first questionnaire, and 32.3% in the second, showing an slight decrease. 16% mentioned programming both before and after, indicating different students responding on the two different questionnaires.

For both the male and female students, there was an increase in those who didn't know or gave no response when asked about the content of a first year Computer Science course. For female students, the percentages were 26.7% on the first questionnaire and 40% on the second, and for male students, 6.5% and 16.1%.

For female students, when asked about course content, 60% said programming on the first questionnaire and 53.3% on the second, compared to 45.2% for male students on the first,

	Possible jobs		*Personal goal*	
	Before	*After*	*Before*	*After*
All				
Don't know/no response	21.7	19.6	37.0	30.4
Programmer	67.4	71.7	30.4	26.1
Development/design	19.6	21.7	8.7	13.0
Networking-related	19.6	28.3	4.3	4.3
Analyst/system analyst	17.4	19.6	6.5	6.5
Web-related	8.7	13.0	2.2	8.7
System administration	6.5	10.9	0.0	2.2
Technician	4.3	13.0	2.2	2.2
Degree requirement unlikely	19.6	23.9	4.3	13.0
Female				
Don't know/no response	33.3	13.3	53.3	26.7
Programmer	53.3	66.7	20.0	13.3
Development/design	20.0	20.0	0.0	13.3
Networking-related	13.3	20.0	0.0	6.7
Analyst/system analyst	26.7	26.7	6.7	6.7
Web-related	13.3	33.3	6.7	20.0
Technician	0.0	13.3	0.0	6.7
Consultant	0.0	13.3	0.0	6.7
Database-related	0.0	13.3	0.0	13.3
Degree requirement unlikely	13.3	33.3	6.7	20.0
Male				
Don't know/no response	16.1	22.6	29.0	32.3
Programmer	74.2	74.2	35.5	32.3
Development/design	19.4	22.6	12.9	12.9
Networking-related	22.6	32.3	6.5	3.2
Analyst/system analyst	12.9	16.1	6.5	6.5
System administration	9.7	12.9	0.0	3.2
Technician	6.5	12.9	3.2	0.0
Research	12.9	0.0	12.9	0.0
Degree requirement unlikely	22.6	19.4	3.2	9.7

Table 9: Responses about which jobs one would be qualified for with a Computer Science degree, and which job the respondents would like personally

	Before	*After*
All		
Don’t know/no response	13.0	23.9
Programming	50.0	50.0
Hardware	17.4	10.9
How computers work	13.0	8.7
How to use a computer	10.9	0.0
Algorithms	4.3	15.2
Female		
Don’t know/no response	26.7	40.0
Programming	60.0	53.3
Hardware	13.3	6.7
How to use a computer	20.0	0.0
Algorithms	13.3	6.7
Networks	13.3	6.7
Software	13.3	6.7
Programming languages	13.3	0.0
Male		
Don’t know/no response	6.5	16.7
Programming	45.2	48.4
Hardware	19.4	12.9
How computers work	16.1	9.7
Algorithms	0.0	19.4

Table 10: Responses about expected Computer Science course content

and 48.4% on the second. 26.7% of female students said programming both before and after, compared with 25.8% of male students.

4.3 Feedback on the course

In the second questionnaire, students were asked questions about the first year courses. The results are given in Table 11. The majority of the students found the course different to their expectations. When asked an open-ended question about how the course differed from their expectations, 39.1% of the total sample indicated that the course was more theoretical (7 responses), mathematical (1 response) or had more fundamental content (3 responses) than expected; or had less practical (6 responses) or programming (3 responses) content than expected. Only one person commented that the course was less mathematical than expected.

Of the sample, 17.4% thought the courses were unenjoyable, 8.7% uninteresting, 4.4% not challenging, and 8.7% not preparation for a career. About a quarter (23.9%) thought the courses were not useful for other courses, which is reasonable as we focus on teaching Computer Science.

In terms of their learning experience, few thought they didn’t learn a lot of facts, and only

	Yes		*No*	n
Were the Computer Science I courses what you expected?	33.3		66.7	42
	A	*N*	*D*	n
The CS I courses were enjoyable	34.8	45.7	17.4	46
The CS I courses were interesting	52.2	37.0	8.7	46
The CS I courses were challenging	67.4	28.3	4.4	46
The CS I courses were suitable preparation for a career as a Computer Science professional	34.8	39.1	8.7	46
The CS I courses were useful for other courses at university	28.3	39.1	23.9	46
I learned a lot of facts from the CS I courses	60.9	28.3	6.5	46
My ability to do independent study improved during the CS I courses	41.3	45.7	8.7	46

Table 11: Opinions about the course

8.7% felt that they didn't improve their ability to do independent study. Note, however, that for each of these questions, a moderate proportion of the sample chose Neutral as an option, so are not prepared to be definite in either direction.

Further analysis was done by gender, whether the course was different from expectations, and whether Computer Studies was taken in Matric using the Fisher Exact Test [Sheskin 2000]. No significant differences were found in the responses of the different groups.

5 Discussion

In general, students' opinions and perceptions show little change, indicating that these are fixed and not influenced by the courses. Even in cases where there is a high percentage of change in opinion, there is often change in both directions (for example, when asked about studying Computer Science to learn programming or whether Computer Science is mainly about programming).

A limitation of this research is the fact that this sample represents those who have succeeded at the mid-year exams. This may mean that we have excluded from the sample the students who may have arrived with the least knowledge of Computer Science, and for whom the course would have been of most benefit. This is a problem we need to consider for further research.

5.1 Understanding of Computer Science and computing careers

There was a significant change in students' own assessment of their understanding of Computer Science, and with further analysis, this change was shown to be significant amongst women, those who did not study Computer Studies in Matric, those who had not programmed and those who were encouraged to study a science degree. For all of these groups, their prior assessment of their understanding was low, and this change represents a real shift in their assessment of their knowledge.

However, when considering their actual knowledge, half the sample said programming on the first questionnaire and half the sample said programming on the second questionnaire, and there were no differences between those who believed that they had an understanding of Computer Science and those who did not. Looking at the responses given by more than 10% of the sample, algorithms was mentioned in the second survey and not in the first, and software, how computers work and how to use a computer, occurred in the first survey at the 10% level, but not the second. This represents some shift in understanding, although many students still see programming as the thing they will learn in Computer Science, suggesting that this perception has not been affected by the course. Two facts mitigate against this interpretation: first, only a quarter of the sample gave programming before and after, suggesting shifts in both directions; and second, only 9% of the sample in the first questionnaire and 15% in the second questionnaire only mentioned programming, indicating that in general, the perception is that programming is part of Computer Science, rather than all of Computer Science. This suggests that students have a broad understanding of Computer Science, or at least broader than just programming (though unfortunately not due to the course).

Assessing the students' understanding of the jobs available for Computer Science graduates, shows that again programming is predominant, at around 70% in both questionnaires, but with only 17% in both questionnaires giving only programming, again showing that there is some breadth of knowledge. Around 20% of the sample chose jobs that are very unlikely to require a Computer Science degree, and worryingly, in the second questionnaire, 13% of the sample indicated that a Computer Science degree qualified one for the job of technician.

In terms of their own job prospects, programming was at around 30%, and about a third did not know, indicating that many students are unsure about their future direction.

An interesting fact that came to light when assessing students' perceptions of careers is that there are very few job titles for which one can state definitely that they require a Computer Science degree: researcher is one, but for many other jobs there are multiple routes to these positions, for example, programmer, system administration, networking. This diversity of routes may lead to the confusion experienced by students.

The results from our research are similar to those of Greening [1998], Nielsen *et al.* [1998] and Herbert [2000] where respondents appeared to have little understanding of the nature of Computer Science or the types of careers that are available.

Questions relating to the availability of good jobs which appear in Table 3 and Table 7 show that students are positive about their prospects even if they do not know what they are. This agrees with the results of Herbert [2000].

Both male and female students became more uncertain about the content of Computer Science courses (or perhaps they felt there are so many aspects to Computer Science that they were daunted in their attempt to write down their understanding). Women were more uncertain on both questionnaires than men, which is interesting in light of the significant change in their own assessment of their understanding. There was slight decrease in the number of women who said programming and a slight increase in the number of men, with more women than men mentioning programming.

Female students became aware of more jobs during the year, particularly programming. They also became more specific in terms of their own career goals – on the first questionnaire half the sample didn't respond, compared to a quarter on the second questionnaire. They also showed an increase in their awareness of careers for which a degree is unlikely to be required, specifically web-related jobs and technician.

Male students appeared to have less knowledge later in the year – on the second questionnaire, almost a quarter did not respond when asked about what jobs could be done with a degree, and almost a third did not respond when asked about personal goals.

Comparing these results to those of Herbert [2000] is interesting. Far more students said they didn't know or didn't respond in this research, and far fewer gave vague answers – in fact, most answers were specific.

5.2 Relationship between Computer Science and mathematics

Although the FAC course deals with mathematical proofs relating to graph theory, as well as a mathematical model of a program, the BCO course deals with logic and the LOC course deals with theory of computation, a significant proportion of students changed their minds about how closely mathematics and Computer Science are related. This is clearly an issue for concern, as we do believe there are strong links between the two disciplines and choose to teach material in first year to highlight that fact. This result contradicts the finding by Scragg and Smith [1998] that students believe that mathematics plays a large role in Computer Science.

A possible explanation is that the other first year mathematical science courses that the majority of students do (Mathematics I Major, and Computational and Applied Mathematics I) focus on continuous mathematics and that the students do not see the link between these subjects and the more discrete mathematics shown in the Computer Science courses. Without understanding why students give the answers they have, it is not possible to reach a definite answer, and this is an area for further research.

Further analysis showed that significant differences were found for male students, those who had done Computer Studies for Matric and those who had programmed before, and those not encouraged to do a science degree. Anecdotal information has identified male students who have programmed before as those who are most likely to assume they know the course material already even though most often they only know how to program and know very little Computer Science. It would have been our expectation that this group would arrive with the idea that Computer Science and mathematics are separate disciplines and finish with an understanding of the links. Why the opposite is the case could possibly could be explained in terms of the continuous/discrete split, if much of their prior programming experience had involved continuous mathematics. This requires further research.

5.3 Female Computer Scientists

Another question where there were significant differences in the proportion of changed answers asked whether the respondent knew any women Computer Scientists in industry or academia. Our expectation is that there should be 100% yes response on the second questionnaire as in both 2000 and 2002 a female lecturer was involved in the course (although only for a small part of the year). Only half of the sample said yes on the second questionnaire. An unpalatable explanation is that the female lecturer was not recognised as a Computer Scientist; less unpalatable explanations relate to the students' interpretation of the questionnaire. For example, 'know' could have been interpreted as 'know' in the sense of being friends with, as opposed to being aware of.

On further analysis, the groups that showed significant differences were female students, those who did not do Computer Studies in Matric, those who had not programmed and those who were not encouraged to study a science degree. The significant change shown by female students could be explained by female students being more aware of the gender of their lecturers as they are seeking suitable role models. Explanations for the significant changes for the other groups are not immediate.

The statements in the second part of Table 7 also relate to gender issues. The results are mixed, although most questions show more (but not significant) change in a direction away from gender-neutral. This is a concern as we wish to retain the female students we have, and a more sexist atmosphere in the class may make the environment less pleasant.

5.4 Working with computers

In Table 7, the only two statements with significant differences in changed proportions deal with working with computers, and whether Computer Science is interesting. In both cases, around 20% of the sample became more in agreement that working with computers is boring or not interesting. Most of the changes of opinion are from positive to neutral as opposed to a shift to negative. Although this is somewhat disappointing, it must be born in mind that we do not have any data to compare this with, so it may be the case that a more traditional first year Computer Science course focussed around programming, would have led to more negative responses. Additionally, many of the students (67.4%) found the course challenging, and it is our experience that students can be much more negative about challenging courses.

The change to a more negative attitude is consistent with the research of Finnie [1987], Burger and Blignaut [2004] and Staehr *et al.* [2001] where attitudes were more negative after courses.

In the research of Beyer *et al.* [2005], it was found that on average, male Computer Science major students became more positive about computers being fun over time, whereas female Computer Science majors become more negative. In the research presented here, the trend was for both male and female students to move away from disagreeing with statements about computers being boring or not interesting.

5.5 Perceptions of the course

The majority of the students found the course different to their expectations, and 30% of the total sample indicated that the course was more theoretical or mathematical or less practical content than expected. Relating this back to the closeness of mathematics and Computer Science, perhaps students distinguish between theoretical and mathematical as concepts. This is supported by the fact that 7 students said the course was too theoretical compared to 1 that said the course was too mathematical. This differs slightly from the sample of Nielsen *et al.* which found their course different, but emphasised that it had both more programming and theoretical material than expected [Nielsen *et al.* 1998].

In light of the high number of students (around two-thirds) who found the course challenging, the fact that there were only 8 students who found the course unenjoyable is a positive sign. About a quarter thought the courses were not useful for other courses, which is reasonable as we focus on teaching Computer Science.

5.6 Summary

In summary, the courses were not what students expected, however, they did not appear to shift students' perceptions appreciably. Students did become more positive about their own assessment of their knowledge of Computer Science. In terms of their actual knowledge, a level of breadth was shown, but programming was predominant as a job option and as expected course content. Since the course does not focus on programming, this could lead to students finding the course differing from their expectations. Although a large proportion felt the course was more theoretical than expected, there was significant shift away from the perception that mathematics and Computer Science are closely related.

The question arises about what has more influence on students – what their lecturers say in class, or what the students are required to do in tutorials, laboratories and preparing for exams. Perhaps the fact that they spend at least 2 hours a week in front of a computer in a laboratory and have assignments based on programming has far more influence than what lecturers say about the breadth of the discipline.

There are some indications that there may be two different groups in the class: those who expect a lot of programming, and then find that there is less than they expect, and a group that expects little programming and finds that there is more than they expect, and further analysis may uncover this.

Clearly these results give us reason to reflect on what we are doing, and how we can change the course to achieve our aims and objectives. It seems possible that any Computer Science course that deals with some programming as our first year courses do, will emphasise the link between the two, but we need to further balance that with other material in the courses. There are a number of examples of breadth-first courses in the literature such as the courses discussed by Phillips *et al.* [2003], Burch and Ziegler [2004], Shannon [2003] and Powers [2003]. The non-programming course offered by Turner and Turner [2005] which focussed on problem-solving in Computer Science is a case in point. This course helped retain students by allowing students to find out if they were likely to succeed in later Computer Science courses, helped with the fact that much of the exposure in high school to computers has little to do with Computer Science, and showed students that there was more to Computer Science than programming. It also helped with the retention of female students.

5.7 Further research

It appears that students may believe that there is more to Computer Science than programming, but they may not be able to articulate what these additional things are because of lack of knowledge. Can we develop a questionnaire that will help with this, perhaps by providing closed questions or a standard instrument for Computer Science such as the one developed by Moore *et al.* [1994]? Even if we take this approach, there is still the issue of what people understand by terms such as 'mathematics'. A possible solution is to do interviews to determine what students mean by the various terms that are in use – this may lead to much richer data and improved understanding.

As mentioned earlier, a limitation of this research is the fact that it does not include those who do not pass the mid-year exams, and who may have the least knowledge of Computer Science. Future research into perception changes could include a questionnaire before these exams.

Additionally, there is some indication that there are two distinct groups in the data whose opinions change in opposite directions, leading to an unclear picture. Further analysis of the data already collected may identify these two groups.

Another aspects we did not try to assess is how much students' perceptions are influenced by what their lecturers say and how much they are influenced by what the students actually do. Although the students may be hearing in lectures about the breadth of Computer Science, the exercises they do in laboratories and their programming assignments (they have both programming and non-programming assignments) may influence their opinions more strongly. Devising a way in which to assess this influence is not a simple task.

6 Conclusion

The aims of this research were to gain an understanding of first year Computer Science students' perceptions of the discipline and what they would study in their courses and to see how these perceptions changed across their first year of study. We surveyed incoming students in two years and then surveyed the same students later on in the same year.

The results of the survey indicate that for most questions students' opinions did not change strongly or if there were changes then these were in both directions. For a few questions there were significant differences between the earlier and later surveys. The students became more confident about their understanding of the nature of Computer Science; the students became less convinced by a link between Computer Science and mathematics; more students became aware of female Computer Scientists; and students became less positive about working with computers or working in the field of Computer Science.

Unfortunately, although the students became more confident about their understanding of Computer Science, we feel that their knowledge of the discipline (as reflected by their answers to various of the questions) did not actually show that they had developed an understanding of the discipline. Another disappointing finding was that the students moved towards feeling that mathematics and Computer Science are not related. This might be because Computer Science's strongest link is to discrete mathematics and our students do mainly continuous mathematics in their first year courses. This is certainly an area for future research.

Looking more closely at some of the data, female students showed a significant change in their assessment of their own understanding of Computer Science, and their awareness of female role models. Male students showed a significant change in their perception of the lack of relationship between Computer Science and mathematics. Female students became more aware of the jobs that they could take up with a Computer Science degree, and male students appeared to become less aware.

This study has given us a better understanding of our students and how their perceptions change during their first year of studying Computer Science but it has also raised a number of questions which we plan to consider in future work.

Acknowledgements: Thanks to all the students who took part in the research and to Hlami Huhlwane and Herman Tshesane for data capture.

References

[Beyer *et al.* 2004] S. Beyer, M. DeKuester, K. Rynes, and J. DeHeer. The temporal stability of gender differences in MIS students. In *Proceedings of the Tenth Americas Conference on Information Systems*, pages 1197–1204, New York, USA, August 2004.

[Beyer *et al.* 2005] S. Beyer, M. DeKeuster, K. Walter, M. Colar, and C. Holcomb. Changes in CS students' attitudes towards CS over time: an examination of gender differences. In *Proceedings of the thirty-six SIGCSE technical symposium on Computer Science education*, pages 392–396, St Louis, Missouri, United States, March 2005.

[Burch and Ziegler 2004] C. Burch and L. Ziegler. Science of computing suite (SOCS): resources for a breadth-first introduction. In *SIGCSE '04: Proceedings of the 35th SIGCSE technical symposium on Computer science education*, pages 437–441, Norfolk, Virginia, USA, March 2004.

[Burger and Blignaut 2004] A. Burger and P. Blignaut. A computer literacy course may initially be detrimental to students' attitudes towards computers. In *SAICSIT '04: Proceedings of the 2004 Annual Research Conference of the South African Institute of Computer*

Scientists and Information Technologists, pages 10–14, Stellenbosch, South Africa, October 2004.

[Clarke and Finnie 1998] M.C. Clarke and G.R. Finnie. Changes in entry-level university students' attitudes to computers for 1985–1997. *South African Computer Journal*, 21:26–32, August 1998.

[Clarke and Teague 1996] V. Clarke and J. Teague. Characterizations of computing careers: Students and professionals disagree. *Computers & Education*, 26(4):241–246, 1996.

[Clarke 2000] M. C. Clarke. Technological experience and technophobia in South African university students. *South African Computer Journal*, 25:12–17, August 2000.

[Craig *et al.* 2002a] A. Craig, V.C. Galpin, R. Paradis, and E. Turner. Panel: What is computing? The perceptions of university computing students. In *Grace Hopper Celebration of Women in Computing*, Vancouver, Canada, October 2002. `www.cs.wits.ac.za/~vashti/sem/CGPT02GHC.html`.

[Craig *et al.* 2002b] A. Craig, R. Paradis, and E. Turner. A gendered view of computer professionals: preliminary results of a survey. *ACM SIGCSE Bulletin*, 34(2):101–104, June 2002.

[Craig 1997] A. Craig. Women and Business Computing: where to from here? *gates*, 4(1):13–19, 1997.

[Denning *et al.* 1989] P.J. Denning, D.G. Comer, D. Gries, M.C. Mulder, A. Tucker, A.J. Turner, and P.R. Young. Computing as a discipline. *Communications of the ACM*, 32(1):9–23, 1989.

[Department of Education 2001] Department of Education. National Strategy for Mathematics, Science and Technology Education in General and Further Education Training. Department of Education, Pretoria, South Africa, 2001. `education.pwv.gov.za/DoE_Sites/Maths%20and%20Science/Final-doc.pdf`.

[Durndell and Thomson 1997] A. Durndell and K. Thomson. Gender and computing: a decade of change. *Computers and Education*, 28(1):1–9, 1997.

[Finnie 1987] G.R. Finnie. Novice attitude changes during a first course in computing: a case study. *Quæstiones informaticæ*, 5(2):56–62, October 1987.

[Greening 1998] T. Greening. Computer Science: Through the eyes of potential students. In *Proceedings of the Third Australasian Conference on Computer Science Education*, pages 145–154, Brisbane, Queensland, Australia, 1998.

[Gürer and Camp 2002] D. Gürer and T. Camp. An ACM-W literature review on women in computing. *ACM SIGCSE Bulletin*, 34(2):121–127, 2002.

[Herbert 2000] T.S. Herbert. *Women role models in Computer Science at the University of the Witwatersrand*. Masters Research Report, Technical Report TR-Wits-CS-2000-16, Department of Computer Science, University of the Witwatersrand, October 2000.

[Lee 1970] R.S. Lee. Social attitudes and the computer revoluation. *Public Opinion Quarterly*, 34:53–59, 1970.

[Moore *et al.* 1994] T. Moore, M. Wick, and B. Peden. Assessing student's critical thinking skills and attitudes toward computer science. *ACM SIGCSE Bulletin*, 26(1):263–267, March 1994.

[Moore 1994] C. Moore. Attitudes towards computers, the influence of sex stereotypes, experience, ownership and mathematics. *Unisa Psychologia*, 21(2):20–27, 1994.

[Nielsen *et al.* 1998] S.H. Nielsen, L.A. von Hellens, A. Greenhill, and R. Pringle. Conceptualising the influence of cultural and gender factors on students' perceptions of it studies and careers. In *SIGCPR '98: Proceedings of the 1998 ACM SIGCPR Conference on Computer Personnel Research*, pages 86–95, March 1998.

[Phillips *et al.* 2003] A.T. Phillips, D.E. Stevenson, and M.R. Wick. Implementing CC2001: a breadth-first introductory course for a just-in-time curriculum design. In *SIGCSE '03: Proceedings of the 34th SIGCSE technical symposium on Computer science education*, pages 238–242, Reno, Navada, USA, February 2003.

[Pike *et al.* 1993] N. Pike, A. Hofer, and S. Erlank. Effect of gender and occupational aspirations on attitudes towards computers. *South African Journal of Education*, 13(1):25–29, 1993.

[Powers 2003] K.D. Powers. Breadth-also: a rationale and implementation. In *SIGCSE '03: Proceedings of the 34th SIGCSE technical symposium on Computer science education*, pages 243–247, Reno, Navada, USA, February 2003.

[Ryan 1994] C.E. Ryan. Raising girls' awareness of computing careers. In *Proceedings of the Fifth International Conference on Women, Work and Computerization*, pages 547–559, Manchester, UK, July 1994.

[Sanders and Galpin 1994] I.D. Sanders and V.C. Galpin. A survey of attitudes to computing at the University of the Witwatersrand. In A. Adam, J. Emms, E. Green, and J. Owens, editors, *IFIP Transactions A-57, Women, Work, and Computerization, Breaking Old Boundaries—Building New Forms,* pages 209–223. Elsevier Science, 1994.

[Sanders and Mueller 2000] I. Sanders and C. Mueller. A fundamentals-based curriculum for first year computer science. In *Proceedings of the thirty-first SIGCSE technical symposium on Computer Science education*, pages 227–231, Austin, Texas, United States, March 2000.

[Scragg and Smith 1998] G. Scragg and J. Smith. A study of barriers to women in undergraduate computer science. *ACM SIGCSE Bulletin*, 30(1):82–86, 1998.

[Shannon 2003] C. Shannon. Another breadth-first approach to CS I using python. In *SIGCSE '03: Proceedings of the 34th SIGCSE technical symposium on Computer science education*, pages 248–251, Reno, Navada, USA, February 2003.

[Sheskin 2000] D.J. Sheskin. *Handbook of Parametric and Nonparametric Statistical Procedures*. Chapman & Hall/CRC, Boca Raton, Florida, Second edition, 2000.

[Smith and Oosthuizen 2003] E. Smith and H.J. Oosthuizen. An investigation of the attitudes of entry-level university students towards computers. In J. Mende and I. Sanders, editors, *Proceedings of SACLA '03*, Pilanesberg, South Africa, June 2003.

[Staehr *et al.* 2001] L. Staehr, M. Martin, and G. Byrne. Computer Attitudes and Computing Career Perceptions of First Year Computing Students. In *Proceedings of Informing Science 2001 – Bridging Diverse Disciplines*, pages 502–509, Krakow, Poland, 2001. eccmmerce.lebow.drexel.edu/eli/pdf/staehrEBKcompu.pdf.

[Swanepoel 1990] C.H. Swanepoel. Meting van belangstelling in die natuurwetenskaplike studierigtig (Measurement of interest in the natural sciences field of study). *South African Journal of Education*, 10(1):75–78, 1990.

[Symonds 2000] J. Symonds. Why IT Doesn't Appeal to Young Women. In E. Balka and R. Smith, editors, *Women, Work and Computerization: Charting a Course to the Future*, IFIP: Volume 172, pages 70–77. Kluwer, 2000.

[Teague and Clarke 1991] G. Teague and V. Clarke. Fiction and Fact: Students' and Professionals' Perceptions of Women in Computer Science. In I. V. Eriksson, B. A. Kitchenham, and K. G. Tijdens, editors, *Women, Work and Computerization*, pages 377–390. North Holland, 1991.

[Teague 1996] J. Teague. A structured review of reasons for the underrepresentation of women in computing. In *Proceedings of the second Australasian conference on Computer science education*, pages 91–98, Melbourne, Australia, 1996.

[The Joint Task Force on Computing Curricula 2001] The Joint Task Force on Computing Curricula. Computing Curricula 2001. *Journal of Educational Resources in Computing*, 1(3):1, September 2001.

[Turner and Turner 2005] E.H. Turner and R.M. Turner. Teaching entering students to think like computer scientists. In *SIGCSE '05: Proceedings of the 36th SIGCSE technical symposium on Computer science education*, pages 307–311, St. Louis, Missouri, USA, February 2005.

[Vally and Dalamba 1999] S. Vally and Y. Dalamba. *Racism, "Racial Integration" and Desegregation in South African Public Secondary Schools*. South African Human Rights Commission, 1999.
www.sahrc.org.za/final_combined_school_racism_report.PDF.

A Questionnaire

The questionnaire presented on the first day of term did not include Section 4.

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Department of Computer Science

This survey concerns research by the Computer Science Department at the University of the Witwatersrand. All information provided will be treated as confidential.

The survey should take less than 15 minutes to complete.

The University of the Witwatersrand is committed to a policy of non-discrimination on the basis of race or gender. Information concerning race and gender is requested in this survey in order to further these ideals, and is not intended to be discriminatory. Students are therefore requested to complete the personal information below.

Please indicate the appropriate response by circling the appropriate answer.

Student number (This will be used for tracking purposes only and will only be seen by the researchers)	
Gender (for statistical purposes only)	Male Female
Age (optional)	

Please circle the appropriate number.

Registered at Wits *for the first time in 2002* and never been to university before.	1
Registered at Wits *for the first time in 2002* and have been to university before but not done any Computer Science courses at university.	2
Registered at Wits *for the first time in 2002* and have been to university before and have done Computer Science courses at university.	3
Registered at Wits *before 2002*, but have not done any Computer Science I courses.	4
Registered at Wits *before 2002* and repeating Computer Science I course(s) at Wits	5
Completed 1st year College of Science at Wits in 2001.	6
Currently registered at Wits for Higher Diploma	7
Other, explain.	8

Matric Maths Symbol	Higher Grade A B C Other	Standard Grade A B C Other
School Attended in Matric Year		
Was the high school you attended:	Co-ed Girls only Boys only	
Population group (for statistical purposes only)	Black White Coloured Indian Other	
Occupation of parents:	Father: Mother:	
What is your home language:		
Have you ever used a computer for: (more than one item can be selected if applicable)	Programming Word processing, spreadsheets E-mail, internet Games, entertainment All of the above Other Never used a computer before	

INSTRUCTIONS

Please complete sections one and two by circling / ticking the CORRECT answer. Mark only one answer for each question. Please provide answers to all questions.

Section 1(a)

Do you have a clear idea of what Computer Science involves ?	Yes	No
Have you ever done a computer course (e.g. Computer Studies at school etc.) ?	Yes	No
Did you do Computer Studies as a Matric subject ?	Yes	No
If you studied Computer Science at school, was it worthwhile ?	Yes	No
Were you encouraged to study a science degree ? (e.g. by parents, teachers etc.)	Yes	No
Do you have a computer at home ?	Yes	No
Do many of your friends use computers ?	Yes	No
Are most of the people you know who like computers men ?	Yes	No
Are you confident of using new technology ? (e.g. VCR, computers, remote controls)	Yes	No
Do you know many women who work with computers ?	Yes	No
Do you think that there are good jobs available for people with Computer Science degrees ?	Yes	No
Do you think Computer Science and mathematics are closely related ?	Yes	No
Do you know any women computer scientists in industry / academia ?	Yes	No
Do you think of a computer scientist as a ‘nerd’ who talks / thinks only about computers ?	Yes	No
Do you plan to major in Computer Science ?	Yes	No
Was Computer Science your first subject choice ?	Yes	No
Are you interested in learning how to use a computer ? (e.g. word processing, spreadsheets etc.)	Yes	No
Are you interested in learning the technical details about computers ? (e.g. computer hardware, engineering, networking etc.)	Yes	No
Are you interested in learning the fundamentals of computer science ? (e.g. algorithms, data structures etc.)	Yes	No
Are you interested in learning about scientific computing ? (e.g. DNA sequencing, 3D graphics, modelling / simulation etc.)	Yes	No
Are you interested in learning the applications of computers ? (e.g. Artificial Intelligence, Database design etc.)	Yes	No
Are you studying Computer Science to learn programming ?	Yes	No
Would you classify yourself (or do others classify you) as a computer nerd ?	Yes	No
Do you know anyone who has studied Computer Science ?	Yes	No

Do you know anyone who works with computers as a profession ?	Yes	No

What type of work do they do ?
Male:

Female:

Section 1(b)

How would you rate your skills at mathematics, analytical thinking and problem solving ?	Good	Average	Poor
Do you prefer working on projects alone rather than in groups ?	Usually	Some times	Never
If you have a computer at home, how often do you use it per week ?	< 2 hours	2-15 hours	> 15 hours
If you don't have a computer at home, how often do you use a computer per week ?	< 2 hours	2-15 hours	> 15 hours
Do you read computer magazines or visit computer stores ?	Often	Some times	Never

Section 2

Please circle / tick the answer which most closely reflects your view.

Computer Science involves mainly programming.	Agree	Neutral	Disagree	Don't Know
Working with computers is boring.	Agree	Neutral	Disagree	Don't Know
I would expect the top science student to be male.	Agree	Neutral	Disagree	Don't Know
I am confident that women can learn Computer Science.	Agree	Neutral	Disagree	Don't Know
Boys like computer games more than girls.	Agree	Neutral	Disagree	Don't Know
Computer Science, Engineering and Maths are more appropriate fields for men than for women.	Agree	Neutral	Disagree	Don't Know
Computer Science is not interesting because it involves working with machines instead of people.	Agree	Neutral	Disagree	Don't Know
I expect to see mostly men in Computer Science classes.	Agree	Neutral	Disagree	Don't Know
I am interested in learning to use computers to solve practical problems; not in learning about the computer itself.	Agree	Neutral	Disagree	Don't Know
I would prefer a male lecturer / supervisor to a female.	Agree	Neutral	Disagree	Don't Know
It is difficult to find interesting jobs in computer science.	Agree	Neutral	Disagree	Don't Know
Computer Science work involves mainly word processing.	Agree	Neutral	Disagree	Don't Know
Men make better scientists than women.	Agree	Neutral	Disagree	Don't Know
Men are better at technical subjects than women are.	Agree	Neutral	Disagree	Don't Know
There are many jobs for people who have studied computer science.	Agree	Neutral	Disagree	Don't Know

Section 3

Please provide brief answers to the following questions.

What jobs would you be qualified to do if you earn a Computer Science degree ?   Don’t know
What job would you like to have if you complete a Computer Science degree ?   Don’t know
What would you expect to learn in a Computer Science course ?
Describe a computer nerd / geek / hacker

Have you ever met someone who fits this description ?	Yes	No

Section 4

Please provide brief answers to the following questions.

Were the Computer Science I courses what you expected ?	Yes	No

If no, how did they differ from your expectations ?
Don't know

Please circle / tick the answer which most closely reflects your view.

The CS I courses were enjoyable	Agree	Neutral	Disagree	Don't Know
The CS I courses were interesting	Agree	Neutral	Disagree	Don't Know
The CS I courses were challenging	Agree	Neutral	Disagree	Don't Know
The CS I courses were suitable preparation for a career as a Computer Science professional	Agree	Neutral	Disagree	Don't Know
The CS I courses were useful for other courses at university	Agree	Neutral	Disagree	Don't Know
I learned a lot of facts from the CS I courses	Agree	Neutral	Disagree	Don't Know
My ability to do independent study improved during the CS I courses	Agree	Neutral	Disagree	Don't Know

Any other comments on the Computer Science I courses ?